

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Yasuhiko WAKABAYASHI

Title: EQUALIZER CIRCUIT AND
EQUALIZING METHOD

Appl. No.: Unassigned

Filing Date: April 10, 2000

Examiner: Unassigned

Art Unit: Unassigned

UTILITY PATENT APPLICATION
TRANSMITTAL

Assistant Commissioner for Patents
Box PATENT APPLICATION
Washington, D.C. 20231

Sir:

Transmitted herewith for filing under 37 C.F.R. § 1.53(b) is the nonprovisional utility patent application of:

Yasuhiko WAKABAYASHI

Enclosed are:

- [X] Specification, Claim(s), and Abstract (18 pages).
- [X] Formal drawings (5 sheets, Figures 1-5G).
- [X] Declaration and Power of Attorney (2 pages).
- [X] Assignment of the invention to NEC CORPORATION.
- [X] Assignment Recordation Cover Sheet.
- [X] Claim for Convention Priority w/ 1 certified document
- [X] Information Disclosure Statement. (2 pgs)
- [X] Form PTO-1449 with copies of 1 listed reference(s).

The filing fee is calculated below:

	Claims as Filed	Included in Basic Fee	Extra Claims	Rate	Fee Totals
Basic Fee				\$690.00	\$690.00
Total Claims:	8	- 20	= 0	x \$18.00	= \$0.00
Independents:	2	- 3	= 0	x \$78.00	= \$0.00
If any Multiple Dependent Claim(s) present:			+	\$260.00	= 0
				SUBTOTAL:	= \$690.00
[]				Small Entity Fees Apply (subtract ½ of above):	= \$0.00
				Assignment Recordation fee:	= \$40.00
				TOTAL FILING FEE:	= \$730.00

- [X] A check in the amount of \$730.00 to cover the filing fee is enclosed.
- [] The required filing fees are not enclosed but will be submitted in response to the Notice to File Missing Parts of Application.
- [X] The Assistant Commissioner is hereby authorized to charge any additional fees which may be required regarding this application under 37 C.F.R. §§ 1.16-1.17, or credit any overpayment, to Deposit Account No. 19-0741. Should no proper payment be enclosed herewith, as by a check being in the wrong amount, unsigned, post-dated, otherwise improper or informal or even entirely missing, the Assistant Commissioner is authorized to charge the unpaid amount to Deposit Account No. 19-0741.

Please direct all correspondence to the undersigned attorney or agent at the address indicated below.

Respectfully submitted,

Date April 10, 2000

FOLEY & LARDNER
Washington Harbour
3000 K Street, N.W., Suite 500
Washington, D.C. 20007-5109
Telephone: (202) 672-5407
Facsimile: (202) 672-5399

By

Phillip J. Artiola

Reg. No.
38,819

for /

David A. Blumenthal
Attorney for Applicant
Registration No. 26,257

Specification

Title of the Invention

Equalizer Circuit and Equalizing Method

5 Background of the Invention

The present invention relates to an equalizer circuit and equalizing method and, more particularly, to an equalizer circuit and equalizing method for preventing waveform distortion and interference waves (noise) in multipath fading.

10

In data transmission of a high-speed radio ATM (Asynchronous Transfer Mode) system for multimedia mobile communication of 20 to 30 Mbps using a 5.2-GHz band, an equalizing function is used to prevent data quality degradation in multipath fading.

15

A technique using this equalizing function has been proposed by the present applicant/assignee. This technique proposes a radio data communication terminal for narrowband modulation system, in which a tap coefficient for an equalizer is set after a frequency offset value for operating a phase rotation means is obtained using, e.g., a shortest preamble.

20

As shown in Fig. 3, the equalizer circuit for performing the above equalizing function comprises a carrier sensor 6 for sensing the presence/absence of an input carrier and an equalizer unit 7 for receiving an output from the carrier sensor 6. The equalizer unit 7

25

is comprised of a memory unit 8, phase rotation unit 9,
phase difference detector 10, average value detector 11,
integrator 12, vector converter 13, transmission line
characteristic estimating unit 14, a tap coefficient
5 setting unit 15, and equalizer 16.

The carrier sensor 6 senses the
presence/absence of a carrier in accordance with an RSSI
(Received Signal Strength Indicator) signal Q
representing the reception level from an RF (Radio
10 Frequency) converter (not shown). The carrier sensor 6
then detects the start of a reception signal and outputs
a carrier sense signal R to the equalizer unit 7 for a
time interval from time when detecting the start of
reception data to time when receiving a demodulation
15 data end signal S of a one-pulse signal for stopping the
equalizer unit 7.

The memory unit 8 receives a reception data
signal P for an arbitrary period to control the output.
The phase rotation unit 9 rotates the phase of the
20 output signal from the memory unit 8 through a necessary
angle. The phase difference detector 10 obtains the
current angle and the angle of a PN (Pseudo Noise) code
sequence obtained upon the lapse of one period. The
phase difference detector 10 then obtains the difference
25 between these two angles.

The average value detector 11 integrates the
phase difference from the phase difference detector 10 a

predetermined number of times. The average value
detector 11 then divides the integrated value by the
predetermined number of times to obtain the average
value of the average phase difference per symbol. The
5 integrator 12 integrates the average value from the
average value detector 11 in units of symbols. The
vector converter 13 converts the output from the
integrator 12 into a real part amplitude value and an
imaginary part amplitude value. The vector converter 13
10 outputs these amplitude values to the phase rotation
unit 9.

The transmission line characteristic
estimating unit 14 obtains the transmission line
characteristics of the one-period PN code sequence for a
15 preamble period using the signal obtained upon phase
rotation in the phase rotation unit 9. The tap
coefficient setting unit 15 obtains a tap coefficient
necessary for the equalizer 16 in accordance with the
transmission line characteristics obtained by the
20 transmission line characteristic estimating unit 14.
The tap coefficient setting unit 15 then sets the tap
coefficient in the equalizer 16. The equalizer 16
equalizes the output from the phase rotation unit 9
using a filter having the tap coefficient set by the tap
25 coefficient setting unit 15. The equalizer 16 outputs a
demodulation data signal U. Reception processing is
performed using this demodulation data signal U.

Figs. 4A to 4F show the reception timings of a conventional phase shifter circuit shown in Fig. 3. In this case, the inactive interval of the reception data signal P is long.

5 The carrier sensor 6 determines the presence/absence of a carrier in accordance with the RSSI signal Q from the RF converter (Fig. 4B). The carrier sensor 6 then outputs the carrier sense signal R representing the start of the reception data signal P to
10 the equalizer unit 7 (Figs. 4A and 4C). Upon detecting the start of the reception data signal P, the equalizer unit 7 detects the frequency offset, estimates the transmission line characteristics, and sets the tap coefficient.

15 The equalizer 16 stores the preamble signal having the repeated PN code in the memory unit 8 and performs processing for a period of various initial settings (Fig. 4E) and has a delay accordingly. Upon completion of various initial settings in the equalizer
20 16, the demodulation data signal U is output (Fig. 4G). Upon completion of demodulation, the demodulation data end signal S is output to the carrier sensor 6 (Fig. 4F). At this time, the equalizer unit 7 is always operating in response to a system clock signal T (Fig. 4D) and
25 therefore consumes power. In addition, a long inactive interval decreases the information bit rate.

Figs. 5A to 5G show the reception timings of

the conventional phase shifter circuit shown in Fig. 3. This exemplifies a short inactive interval of the reception data signal P.

The carrier sensor 6 determines the presence/absence of a carrier in accordance with the RSSI signal Q from the RF converter (Fig. 5B) and outputs the carrier sense signal R representing the start of the reception data signal P to the equalizer unit 7 (Figs. 5A and 5C). The equalizer unit 7 detects a frequency offset, estimates the transmission line characteristics, and sets the tap coefficient upon detecting the start of the reception data signal P.

The equalizer 16 stores the preamble signal having the repeated PN code in the memory unit 8 and performs processing for a period of various initial settings (Fig. 5E) and has a delay accordingly. Upon completion of various initial settings in the equalizer 16, the demodulation data signal U is output (Fig. 5G). Upon completion of demodulation, the demodulation data end signal S is output to the carrier sensor 6 (Fig. 5F). At this time, the equalizer unit 7 is always operating in response to a system clock signal T (Fig. 5D) and therefore consumes power.

Since the inactive interval of the reception data signal P is short, a carrier detection signal β representing the leading edge of the carrier sense signal R cannot be detected upon receiving the next

frame during a carrier sense period α . Therefore, the reception operation is performed every other frame, and the demodulation data signal U cannot normally be output.

In the above conventional equalizer circuit, a long inactive interval undesirably decreases the information bit rate. When the next frame is received during the processing period of the demodulation data with a short inactive interval, the carrier sense signal cannot be detected. Data is received every other frame, resulting in a reception error. Since the equalizer unit is always operating in response to the system clock signal, wasteful power is undesirably consumed.

Summary of the Invention

It is an object of the present invention to provide an equalizer circuit and equalizing method capable of normally performing real-time processing even upon receiving a continuous burst signal.

It is another object of the present invention to provide an equalizer circuit and equalizing method which can reduce power consumption.

In order to achieve the above object of the present invention, there is provided an equalizer circuit comprising carrier sensing means for sensing the start of a reception signal on the basis of a signal representing a reception level of the reception signal, first and second equalizing means for equalizing the reception signal, control means for alternately enabling

the first and second equalizing means every frame
reception in accordance with an output from the carrier
sensing means, and switching means for alternately
switching between outputs from the first and second
5 equalizing means every frame reception and outputting
the selected output as demodulation data.

Brief Description of the Drawings

Fig. 1 is a block diagram of an equalizer
circuit according to an embodiment of the present
10 invention;

Figs. 2A to 2N are timing charts showing
operation of switching two parallel equalizers according
to the embodiment shown in Fig. 1;

Fig. 3 is a block diagram of a conventional
15 equalizer circuit;

Figs. 4A to 4G are timing charts of
conventional operation for a long inactive interval; and

Figs. 5A to 5G are timing chats of
conventional operation for a short inactive interval.

20 Description of the Preferred Embodiment

The present invention will be described in
detail with reference to the accompanying drawings.

Fig. 1 shows an equalizer circuit according to
an embodiment of the present invention. Referring to
25 Fig. 1, the equalizer circuit of this embodiment is
comprised of a carrier sensor 1 for detecting the
carrier of an input signal, a carrier sense controller 2

for receiving an output from the carrier sensor 1, gate
circuits 3a and 3b for receiving an output from the
carrier sense controller 2, an equalizer unit 4a for
receiving a reception data signal A and outputs from the
5 carrier sense controller 2 and gate circuit 3a, an
equalizer unit 4b for receiving the reception data
signal A and the outputs from the carrier sense
controller 2 and gate circuit 3b, and a reception data
switching unit 5 for receiving outputs from the
10 equalizer units 4a and 4b and outputting a demodulation
data signal M. Gate signals from the equalizer units 4a
and 4b are output to the carrier sense controller 2.

The carrier sensor 1 detects the start of the
reception data in accordance with an RSSI signal B from
15 an RF converter 21 and outputs a signal representing
this start to the carrier sense controller 2. The
carrier sense controller 2 determines the start of
reception data in accordance with a signal from the
carrier sensor 1 and detects the end of carrier sensing
20 on the basis of demodulation data gate signals J and K
respectively from the equalizer units 4a and 4b.

At the start and end of carrier sensing, the
carrier sense controller 2 generates active-high carrier
sense signals C and D for low-power consumption and
25 real-time processing every other frame. The carrier
sense controller 2 outputs the carrier sense signal C to
the gate circuit 3a and equalizer unit 4a and the

carrier sense signal D to the gate circuit 3b and equalizer unit 4b. The carrier sense signals C and D serve as enable signals for the equalizer units 4a and 4b.

5 The gate circuit 3a masks a system clock signal E and the carrier sense signal C and outputs an active-high clock gate signal F to the equalizer unit 4a. The gate circuit 3b masks the system clock signal E and the carrier sense signal D and outputs an active-high
10 clock gate signal G to the equalizer unit 4b.

 The equalizer unit 4a detects the frequency offset, estimates the transmission line characteristics, and sets the tap coefficient upon receiving the carrier sense signal C. The equalizer unit 4a outputs the
15 demodulation data gate signal J and the demodulation data signal H to the reception data switching unit 5 upon initial setting of an internal equalizer 41a.

 The equalizer unit 4b detects the frequency offset, estimates the transmission line characteristics,
20 and sets the tap coefficient upon receiving the carrier sense signal D. The equalizer unit 4b outputs the demodulation data gate signal K and the demodulation data signal L to the reception data switching unit 5 upon initial setting of an internal equalizer 41b.

25 The reception data switching unit 5 alternately receives the demodulation data gate signal J from the equalizer unit 4a and the demodulation data

gate signal K from the equalizer unit 4b. The reception data switching unit 5 switches (selects) between the demodulation data signal H from the equalizer unit 4a and the demodulation data signal L from the equalizer unit 4b in response to the demodulation data gate signals J and K and outputs the selected demodulation data signal as the demodulation data signal M. Reception processing is performed in accordance with the demodulation data signal M from the reception data switching unit 5.

Figs. 2A to 2N show the switching operation for the two parallel equalizers shown in Fig. 1. The reception data signal A is made up of preamble signals for performing various training operations and information data, as shown in Fig. 2A.

The preamble signals are received by repeating a PN code for a predetermined period. The carrier sensor 6 determines the presence/absence of a carrier in accordance with the RSSI signal B from the RF converter 21 (Fig. 2B). The carrier sensor 6 then outputs the carrier sense signals C and D representing the start of the reception data signal A to the gate circuits 3a and 3b and equalizer units 4a and 4b (Figs. 2C and 2H). Upon outputting the carrier sense signals C and D from the carrier sense controller 2, the equalizer units 4a and 4b detect the frequency offset values, estimate the transmission line characteristics, and set the tap

coefficients using a PN-code one-period signal.

The equalizer units 4a and 4b store the PN codes in an internal memory 42a during the respective initial setting periods (Figs. 2E and 2J) and has delays accordingly. At the end of the demodulation data signals H and L from the equalizer units 4a and 4b, the carrier sense controller 2 stops outputting the carrier sense signals C and D, as will be described later.

The operation of the gate circuits 3a and 3b, equalizer units 4a and 4b, and reception data switching unit 5 will now be described in detail below.

The gate circuits 3a and 3b control to gate the system clock signal E using the carrier sense signals C and D as gate signals (Figs. 2C, 2H, and 2N). While receiving the carrier sense signals C and D, the gate circuits 3a and 3b output the clock gate signals F and G (Figs. 2D and 2I). While receiving the carrier sense signals C and D, the equalizer units 4a and 4b perform the above-mentioned processing using the reception data signal A and clock gate signals F and G. As a result of processing, the equalizer units 4a and 4b output the demodulation data signals H and L to the reception data switching unit 5 (Figs. 2H and 2L). At the same time, the equalizer units 4a and 4b output the demodulation data signals J and K synchronized with the demodulation data signals H and L (Figs. 2F and 2K).

The reception data switching unit 5 selects

the demodulation data signal H or L in accordance with the demodulation data gate signals J and K and outputs the demodulation data signal M (Fig. 2M). At this time, the carrier sensor 2 stops outputting the carrier sense signals C and D upon receiving the demodulation data gate signals J and K.

Since the equalizer units 4a and 4b construct a parallel circuit, these equalizer units can alternately be switched in real time to allow reception processing even if the next frame is received during the carrier sense period. Since the clock gate signals F and G are supplied to the equalizer units 4a and 4b, power consumption can be reduced.

According to the present invention, the two parallel equalizers 41a and 41b in the equalizer units 4a and 4b are alternately switched every frame and operate for reception during only the clock gate period, thereby reducing the power consumption. Real-time processing is allowed even with delays in initial settings for the equalizers in the equalizer units 4a and 4b.

The two parallel equalizers (equalizers in the equalizer units 4a and 4b) are alternately switched every frame reception. Even if a continuous burst signal having a short inactive interval is input, normal processing can be performed in real time. In addition, since the equalizer units 4a and 4b operate for

reception during only the carrier sense period, power consumption can be reduced.

What is claimed is:

1. An equalizer circuit comprising:
 - 2 carrier sensing means for sensing the start of a
 - 3 reception signal on the basis of a signal representing a
 - 4 reception level of the reception signal;
 - 5 first and second equalizing means for equalizing the
 - 6 reception signal;
 - 7 control means for alternately enabling said
 - 8 first and second equalizing means every frame reception
 - 9 in accordance with an output from said carrier sensing
 - 10 means; and
 - 11 switching means for alternately switching
 - 12 between outputs from said first and second equalizing
 - 13 means every frame reception and outputting the selected
 - 14 output as demodulation data.
2. A circuit according to claim 1, wherein
 - 2 said control means alternately outputs first
 - 3 and second carrier sense signals to said first and
 - 4 second equalizing means for a time interval from time
 - 5 when the detection signal is output from said carrier
 - 6 sensing means to time when equalizing processing is
 - 7 complete in said first and second equalizing means, and
 - 8 said first and second equalizing means
 - 9 alternately equalize the reception signal every frame
 - 10 reception in response to first and second carrier sense

11 signals from said control means.

3. A circuit according to claim 2, further
2 comprising first and second gate means for receiving a
3 system clock signal and the first and second carrier
4 sense signals from said control means and supplying an
5 output clock signal to said first and second equalizing
6 means.

4. A circuit according to claim 2, wherein
2 said first and second equalizing means output
3 first and second demodulation data used during
4 equalizing processing to said switching means and output
5 first and second demodulation data gate signals
6 synchronized with the first and second demodulation data
7 to said control means and said switching means,
8 said control means stops outputting the first
9 and second carrier sense signals in response to the
10 first and second demodulation data gate signals, and
11 said switching means alternately outputs the
12 first and second demodulation data in response to the
13 first and second demodulation data gate signals.

5. A circuit according to claim 2, wherein
2 said first and second equalizing means
3 comprise equalizers for setting tap coefficients and
4 memories for storing preamble signals of the reception

5 signal, and
6 said first and second equalizing means detect
7 frequency offset values, estimate transmission line
8 characteristics, and set the tap coefficients at the
9 start of reception of the reception signal.

6. An equalizing method comprising the steps
2 of:

3 detecting the start of a reception signal on
4 the basis of a signal representing a reception level of
5 the reception signal;

6 alternately enabling first and second
7 equalizer units for equalizing the reception signal upon
8 detecting the start of the reception signal; and

9 alternately switching between outputs from
10 said first and second equalizer units every frame
11 reception and outputting the selected output as
12 demodulation data.

7. A circuit according to claim 4, wherein the
2 step of alternately enabling further comprises the step
3 of alternately outputting first and second carrier sense
4 signals as enable signals to said first and second
5 equalizer units for a time interval from time when the
6 start of the reception signal is detected to time when
7 equalizing processing is complete in said first and
8 second equalizer units.

8. A circuit according to claim 5, further
2 comprising the step of alternately supplying a system
3 clock signal to said first and second equalizer units in
4 accordance with the first and second carrier sense
5 signals.

Abstract of the Disclosure

An equalizer circuit includes a carrier sensor, first and second equalizer units, carrier sense controller, and reception signal switching unit. The carrier sensor senses the start of a reception signal on the basis of a signal representing the reception level of the reception signal. The first and second equalizer units equalize the reception signal. The carrier sense controller alternately enables the first and second equalizer units every frame reception in accordance with an output from the carrier sensor. The reception signal switching unit alternately switches between outputs from the first and second equalizer units every frame reception and outputs the selected output as demodulation data.

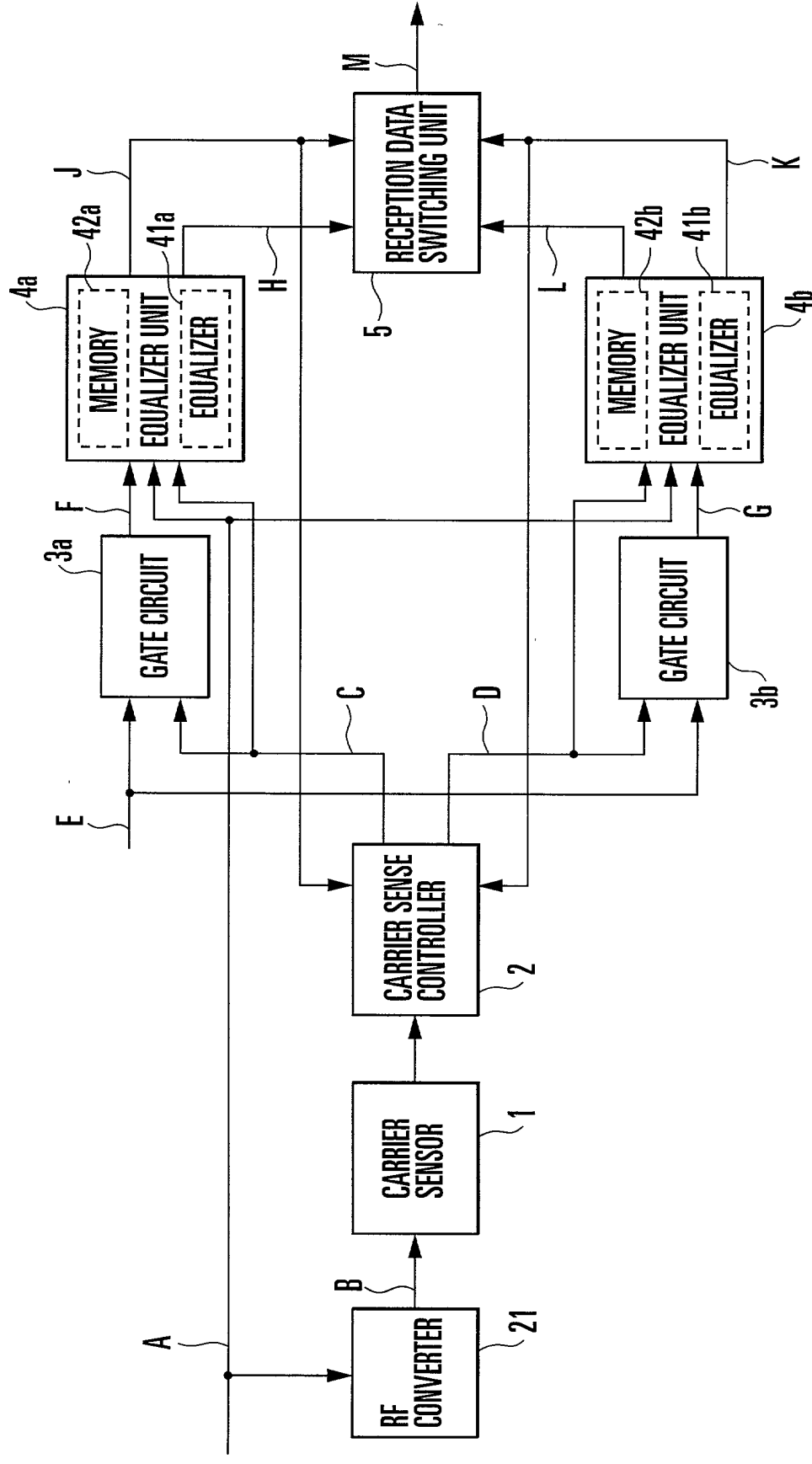
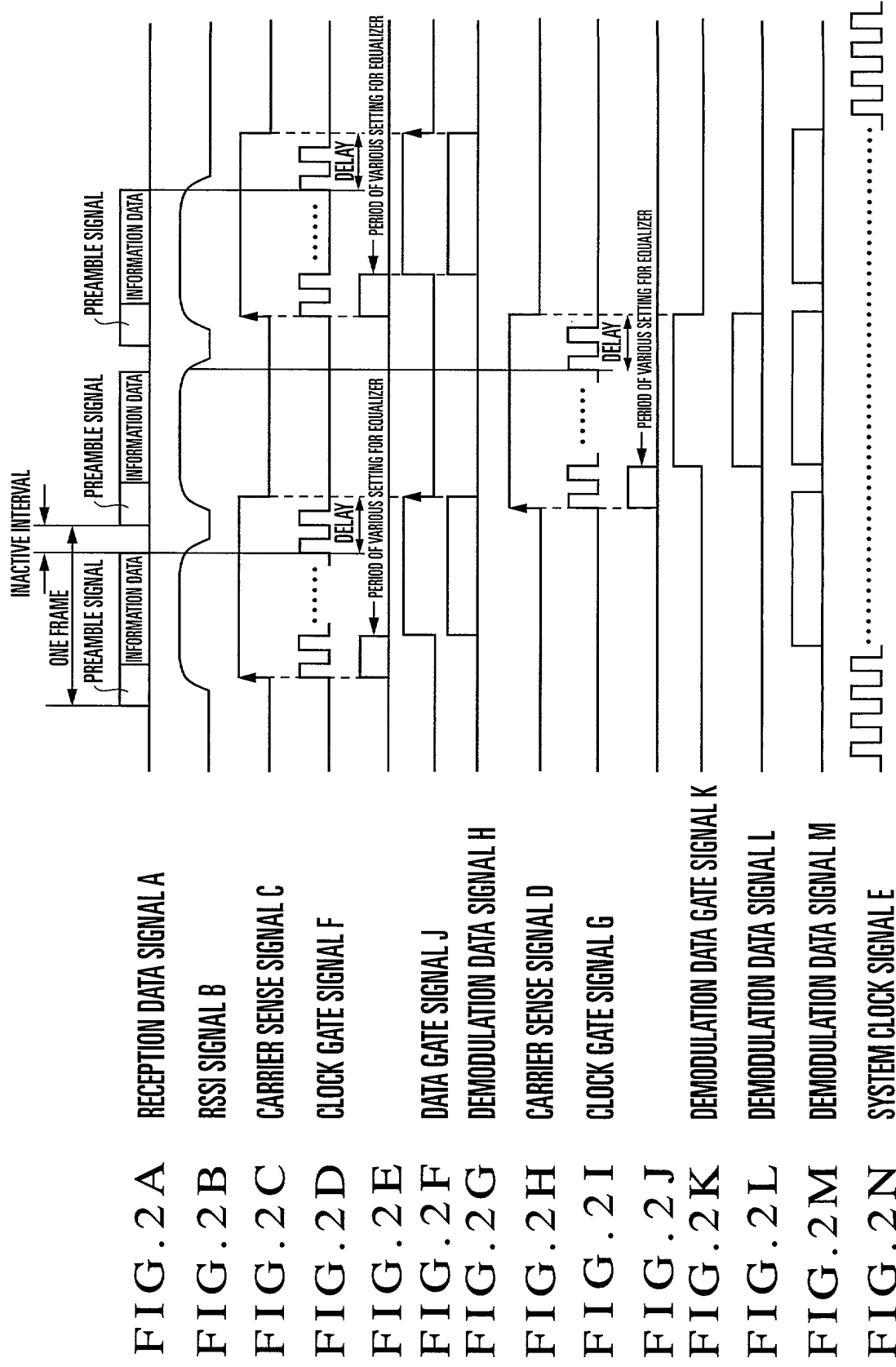


FIG. 1



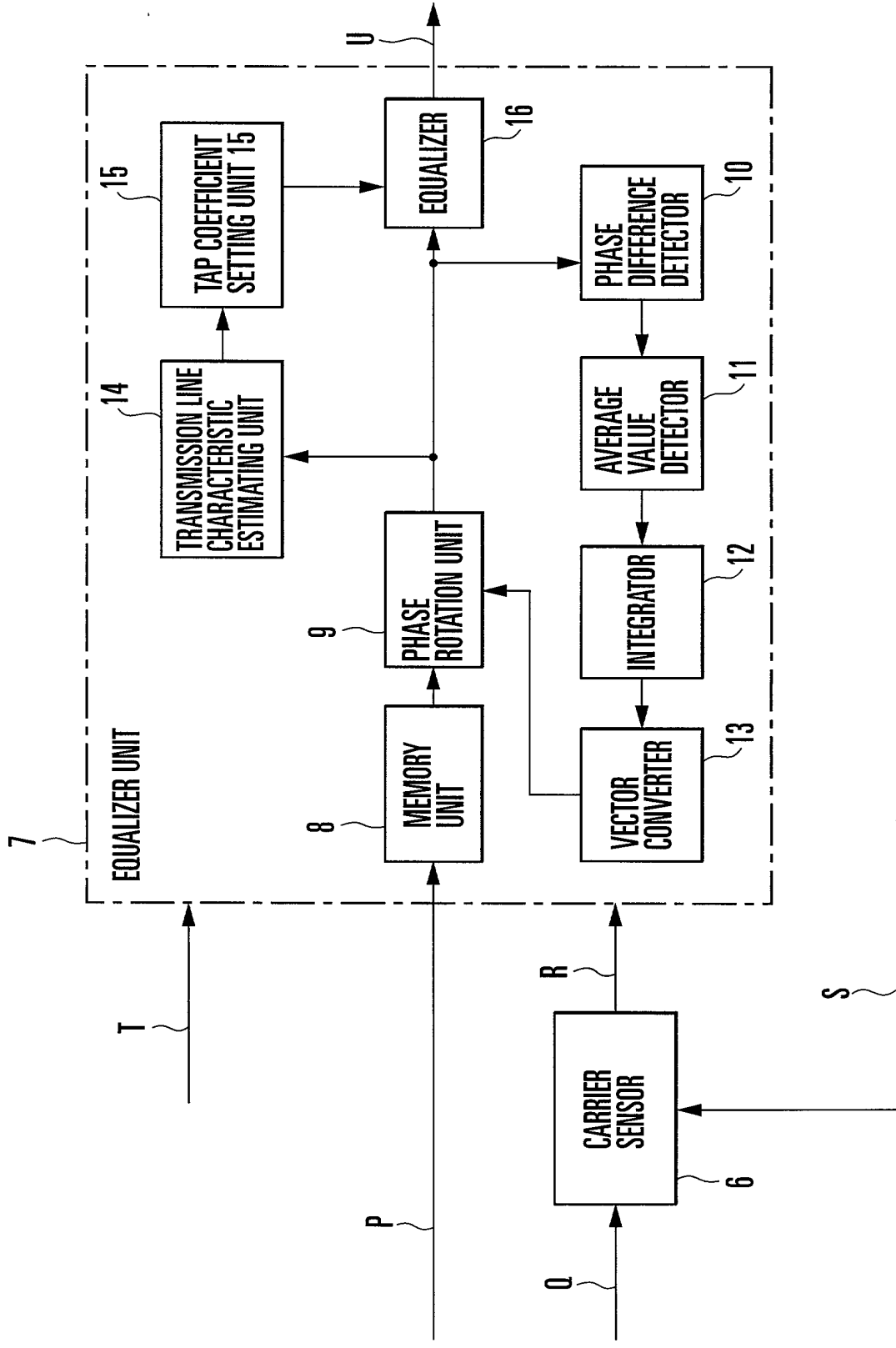


FIG. 3

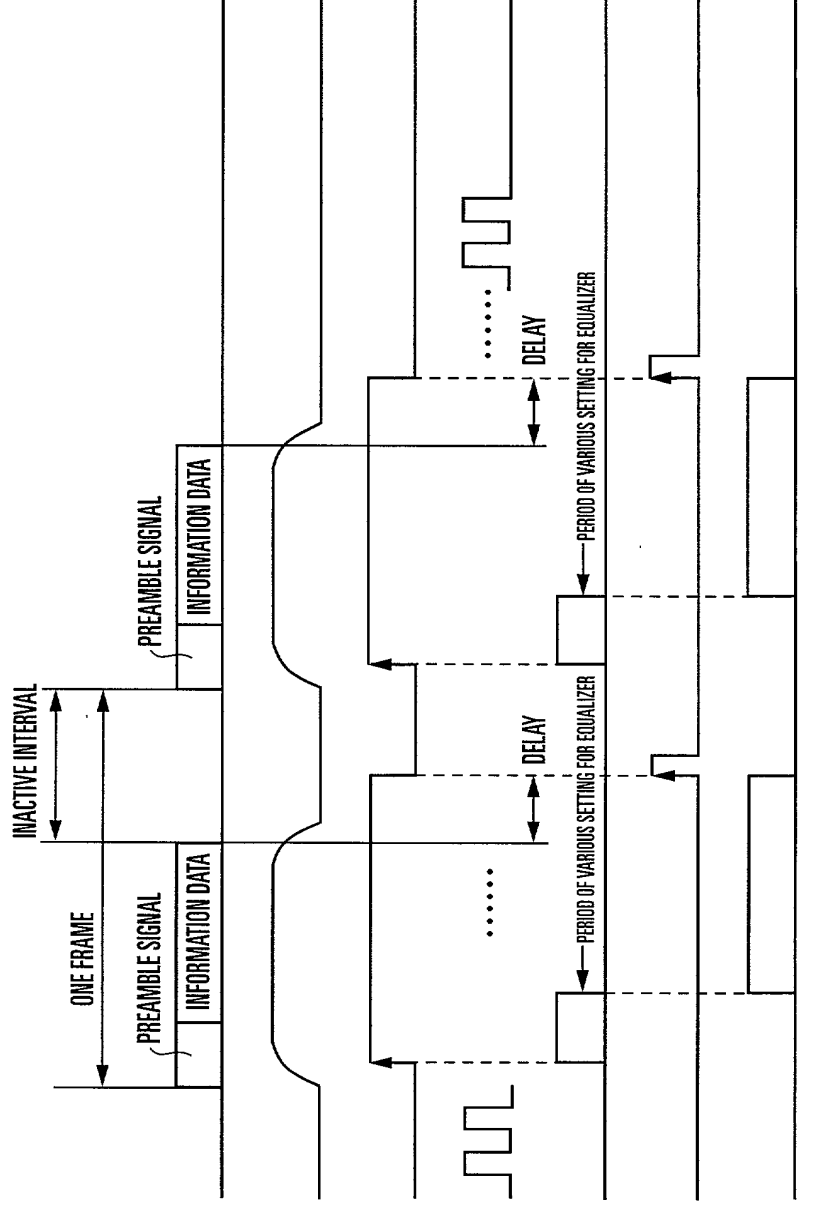


FIG. 4 A RECEPTION DATA SIGNAL P

FIG. 4 B RSSI SIGNAL Q

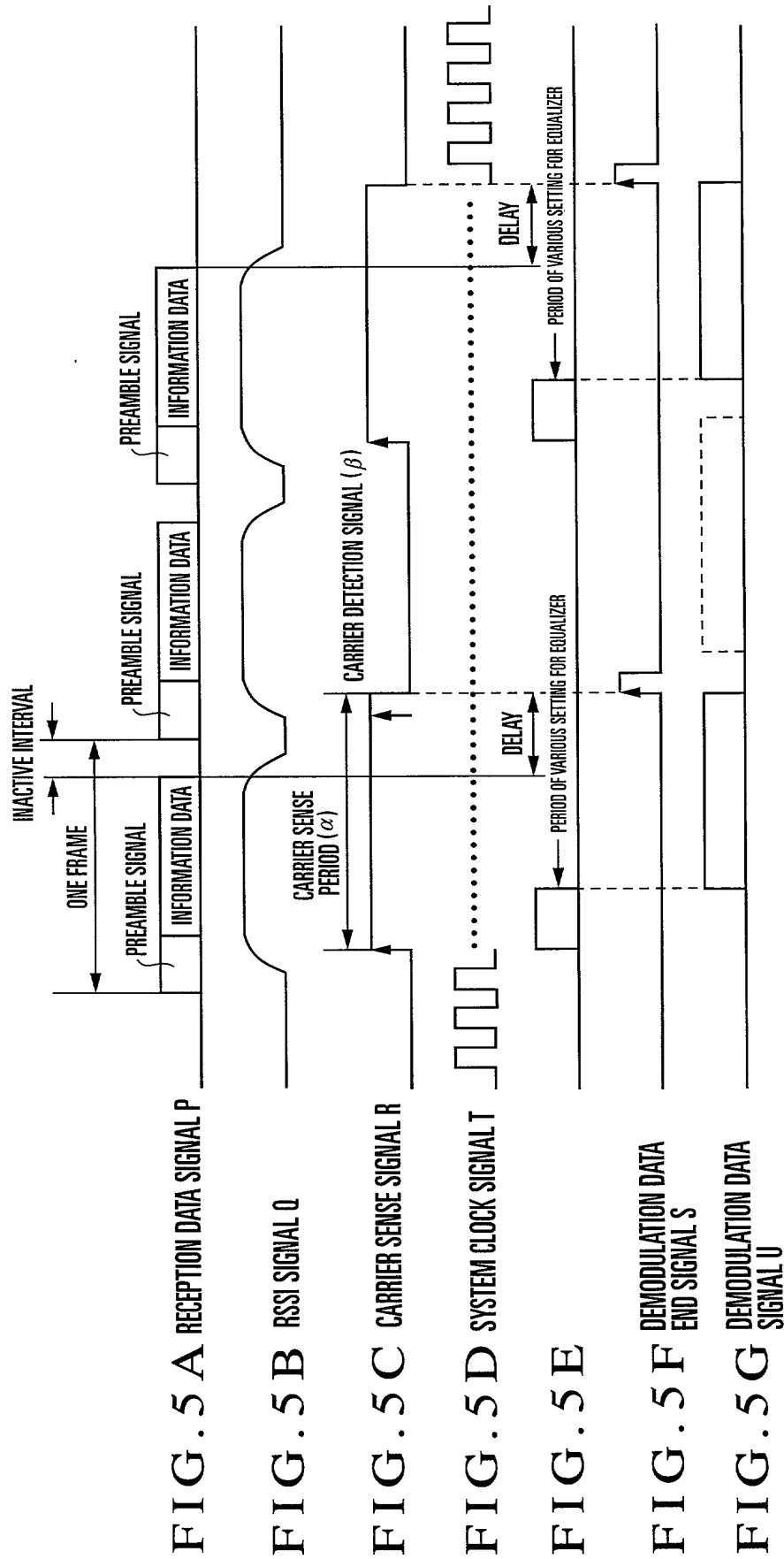
FIG. 4 C CARRIER SENSE SIGNAL R

FIG. 4 D SYSTEM CLOCK SIGNAL T

FIG. 4 E

FIG. 4 F DEMODULATION DATA
END SIGNAL S

FIG. 4 G DEMODULATION DATA
SIGNAL U



DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Equalizer Circuit and Equalizing Method

the specification of which is attached hereto unless the following box is checked:

☐ was filed on _____ as United States Application Number or PCT International Application Number _____ and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is known by me to be material to patentability as defined in Title 37, Code of Federal Regulations § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

NUMBER	COUNTRY	DAY/MONTH/YEAR FILED	PRIORITY CLAIMED
106034/1999	Japan	14/04/1999	Yes

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

APPLICATION NO.	FILING DATE


I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is known by me to be material to patentability as defined in Title 37, Code of Federal Regulations § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

APPLICATION SERIAL NO.	FILING DATE	STATUS: PATENTED, PENDING, ABANDONED

I hereby appoint as my attorneys, with full powers of substitution and revocation, to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: Stephen A. Bent, Reg. No. 29,768; David A. Blumenthal, Reg. No. 26,257; William T. Ellis, Reg. No. 26,874; John J. Feldhaus, Reg. No. 28,822; Patricia D. Granados, Reg. No. 33,683; John P. Isacson, Reg. No. 33,715; Donald D. Jeffery, Reg. No. 19,980; Eugene M. Lee, Reg. No. 32,039; Richard Linn, Reg. No. 25,144; Peter G. Mack, Reg. No. 26,001; Brian J. McNamara, Reg. No. 32,789; Sybil Meloy, Reg. No. 22,749; George E. Quillin, Reg. No. 32,792; Colin G. Sandercock, Reg. No. 31,298; Bernhard D. Saxe, Reg. No. 28,665; Charles F. Schill, Reg. No. 27,590; Richard L. Schwaab, Reg. No. 25,479; Arthur Schwartz, Reg. No. 22,115; Harold C. Wegner, Reg. No. 25,258.

Address all correspondence to FOLEY & LARDNER, Washington Harbour, 3000 K Street, N.W., Suite 500, P.O. Box 25696, Washington, D.C. 20007-8696. Address telephone communications to _____ at (202) 672-5300.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of First or Sole Inventor Yasuhiko Wakabayashi	Signature of First or Sole Inventor <i>Yasuhiko Wakabayashi</i> 	Date Mar. 27, 2000
Residence Address Tokyo, Japan	Country of Citizenship Japan	
Post Office Address c/o NEC Corporation, 7-1, Shiba 5-chome, Minato-ku, Tokyo, Japan		

Full Name of Second Inventor	Signature of Second Inventor	Date
Residence Address	Country of Citizenship	
Post Office Address		

Full Name of Third Inventor	Signature of Third Inventor	Date
Residence Address	Country of Citizenship	
Post Office Address		

Full Name of Fourth Inventor	Signature of Fourth Inventor	Date
Residence Address	Country of Citizenship	
Post Office Address		

Full Name of Fifth Inventor	Signature of Fifth Inventor	Date
Residence Address	Country of Citizenship	
Post Office Address		